

The Transit Bus Niche Market For Alternative Fuels:

Module 9A: Introduction to Transit Costs 1.0

Clean Cities Coordinator Toolkit

Prepared by
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Transit Costs Tool Can Help You Be More Knowledgeable about Alt Fuel Choices

- The Tool provides comparison of costs for various alternative fuel options in transit bus applications:
  - Purchasing buses
  - Building and operating fueling and maintenance facilities
  - Performing bus maintenance
  - Purchasing fuel
- Estimates are provided for different types of costs
  - Capital or “up-front” costs (buses and facilities)
  - Operating costs (maintenance and fuel)
- The Tool also provides estimates for:
  - Annualized costs, based on inputs the user provides about expectations of purchasing schedule and fleet size
  - Breakdown of costs incurred at local and federal level
  - Comparison of cash flow requirements for diesel and an alt fuel transit option
- The Tool enables users to **customize** all data inputs -- this is highly encouraged, because each transit agency has unique circumstances and operational issues / costs

Origins of the Transit Costs 1.0 Tool

- **Transit Costs 1.0*** is developed from the FuelCost 1.0 tool written in 1998 for the Transit Cooperative Research Program, sponsored by the Federal Transit Administration
- FuelCost 1.0 was developed by ARCADIS Geraghty & Miller's Transportation Technologies unit, under contract to National Academy of Sciences, Transportation Research Board (Transit Cooperative Research Program Contract C-8)
- This unit that developed FuelCost 1.0 became part of TIAX LLC in 2002
- **Transit Costs 1.0** is an outgrowth of FuelCost 1.0, but is not associated with the National Academy of Sciences, Transportation Research Board or TCRP Contract C-8)
- In developing **Transit Costs 1.0**, TIAX has kept the general structure of FuelCost 1.0, to be useful for those already familiar with it
  - Transit agencies continue to use FuelCost 1.0, with customized inputs to help them estimate costs

*Transit Costs 1.0 is an outgrowth of FuelCost 1.0 but it not associated with the TCRP program.

Updates in Transit Costs 1.0 - Fuel Price Worksheet Example

- Fuel options have been updated to reflect current trends and interests in alternative fuels for transit fleets
  - – Added
    - Biodiesel 20, Biodiesel 100
    - Diesel Hybrid Electric
  - – Removed
    - Methanol
- Inputs were reviewed and updated where necessary

	A	B	C	D	E	F	G	H
1		FUEL PRICE						
2		10-bus example case						
3								
4		**Diesel**	**CNG**	**LNG**	**Biodiesel 20**	**Ethanol (E85)**	**LPG**	**Hybrid**
5	Sales unit of fuel	gallon	therm (= 100 scf)	gallon	allon	gallon	gallon	gallon
6	Energy content of fuel (BTU/sales unit)	128,400	93,000	75,820	,020	81,445	84,500	128,400
7	Efficiency penalty	0%	-35%	-25%	%	-15%	-35%	12%
8	Fuel economy (mi/sales unit)	4.00	2.15	1.89	0	2.21	1.95	4.55
9		mpg_{diesel}	$mptherm_{CNG}$				mpg_{lpg}	mpg_{hybrid}
10								
11	**Unit price--median ($/unit)**	$ 1.22	$ 0.90	$			1.17	$ 1.22
12	Delivery cost ($/unit)	$ -	$ -	$			-	$ -
13	EPA Superfund excise tax ($/unit)	$ -	$ -	$			-	
14	Subtotal--median ($/unit)	$ 1.2229	$ 0.9008	$			1.1723	$ 1.2229
15	Fuel tax: $0 per diesel gal equiv	$ -	$ -	$			-	$ -
16	**Total fuel cost--median ($/unit)**	**$ 1.22**	**$ 0.90**	**$ 0.69**	**$ 1.24**	**$ 1.35**	**$ 1.17**	**$ 1.22**
17	Price of fuel/million BTU	$ 9.5245	$ 9.6864	$ 9.1005	$ 10.5121	$ 16.6153	$ 13.8732	$ 9.5245
18	Price of fuel/diesel-equivalent gallon	$ 1.2229	$ 1.2437	$ 1.1685	$ 1.3498	$ 2.1334	$ 1.7813	$ 1.2229
19								

Biodiesel 100 and Biodiesel 20 can be toggled in the analysis

Tips for Using the Transit Costs 1.0 Tool

- The model is pre-loaded with default values for all parameters used to calculate the costs of various fuel options.
- To perform a cost analysis, begin with the first five worksheets (i.e., those data worksheets with the five left-most sheet tabs), which are entitled General Inputs, Bus Data, Biodiesel Data, Fuel Price, Facilities, and Costs—Median.
- Start with the General Inputs worksheet and work through the other four worksheets listed on the left. Look for the following items:
  - Cells with **Blue text**: These cells allow user input, and initially contain default values. The user should replace any of these values with values that are appropriate for the particular transit fleet being evaluated.
  - Cells with **Grey background**: These cells are initially blank. The user can either leave these cells blank or enter a value appropriate for the particular transit fleet.
- The user can review the results of the cost analysis in four summary Cost and Cash Flow worksheets and six types of charts (the ten sheet tabs to the right of Facilities).

Transit Costs 1.0 User Inputs: General Inputs Worksheet

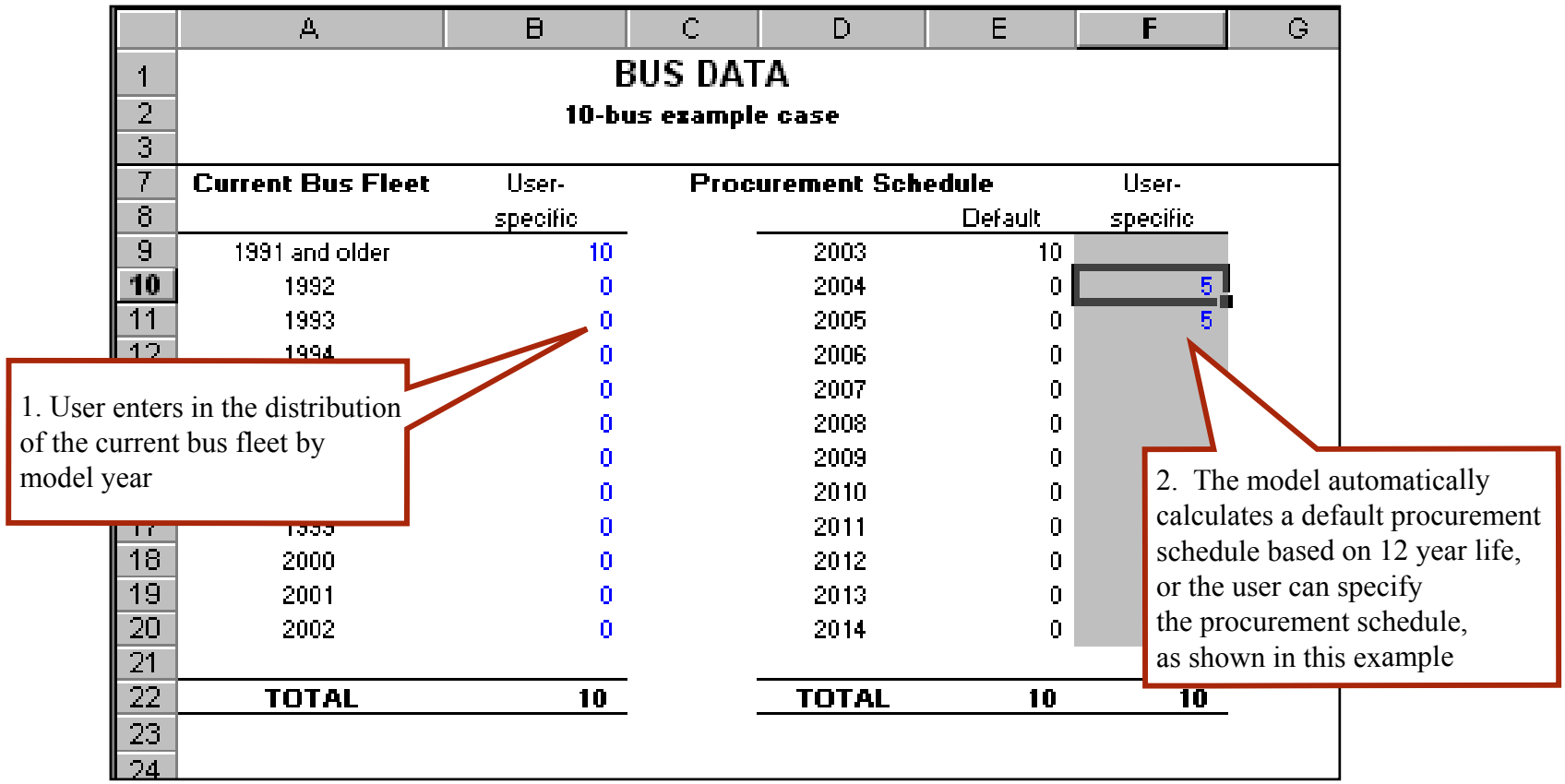
In this worksheet, user enters inputs specific to the transit fleet and can choose an alternative fuel for the cash-flow analysis

	A	B	C	F	G	H	I
1		**GENERAL INPUTS**					
2		**10-bus example case**					
3							
4		Scenario name	10-bus example case				
5							
6		Current year	2003				
8		Sales tax					
9		Sales tax rate	7.75%				
10		Additional state tax for fuel only*					
11		Percentage-based	0%				
12		Cost-based ($/equiv diesel gal)	$0.00				
13		Total median fuel sales tax ($/equiv diesel gal)	$0.00				
14							
15		Amortization parameters					
16		Discount rate	8.00%				
17		Fueling facility and maintenance facility life (years)	20				
19		Annual miles per bus	41,667				
20							
21							
23		Are buses parked indoors? (Enter Y or N)	N				
25		Cost sharing					
26		Federal share of diesel-related capital costs	80%				
27		Federal share of alternative-fuel-related capital costs	80%				
29		Electricity costs (for CNG compressor station)					
30		Unit electricity price ($/kWh)	$0.08				
31		Demand charge ($/kW per month)	$10.00				
33		Alternative fuel to use for cash-flow analysis	**CNG**				
34		*If biodiesel is chosen, fuel blend must be chosen*	Biodiesel 20				
35							

In this example, the user is evaluating the purchase of 10 buses
- approx. 42,000 miles per year avg
- expects 80% federal cost sharing
- an interest in CNG

Transit Costs 1.0 User Inputs: Bus Data Worksheet

User provides information about current bus fleet, has option to enter information about expected procurement



BUS DATA

10-bus example case

Current Bus Fleet	User-specific
1991 and older	10
1992	0
1993	0
1994	0
	0
	0
	0
	0
	0
2000	0
2001	0
2002	0
TOTAL	**10**

Procurement Schedule	Default	User-specific
2003	10	
2004	0	5
2005	0	5
2006	0	
2007	0	
2008	0	
2009	0	
2010	0	
2011	0	
2012	0	
2013	0	
2014	0	
TOTAL	**10**	**10**

1. User enters in the distribution of the current bus fleet by model year

2. The model automatically calculates a default procurement schedule based on 12 year life, or the user can specify the procurement schedule, as shown in this example

Transit Costs 1.0 User Optional Inputs: Facility Capital Costs

User can accept default values for fueling facility costs and modification costs for maintenance facilities or can input information specific to the transit agency

	A	B	C	D	E	F	G	H	I
1				FACILITY CAPITAL COSTS					
2				10-bus example case					
3									
4			Diesel	CNG	LNG	Biodiesel 20	Ethanol	LPG	Hybrid
5		Fuel required per weekday	334	622					294
6			gal	therms					gal
7		Fueling facility tank capacity (gal)			5				000
8		CNG fueling facility compressor capacity (cfm)		100					
9		Natural gas supply pressure (psia) (CNG only)		65					
10									
11		Fueling facility capital cost							
12		Default estimate--median	$ -	$ 275,000	$ 237				-
13		User-specific estimate		$ 50,000					
14									
15		Maintenance facility modification capital cost							
16		Default estimate--median	$ -	$ 125,000	$ 125				-
17		User-specific estimate		$ 0					
18		**Total facility capital costs--median**	**$ -**	**$ 50,000**	**$ 362,**				-
19									
20									
21		Fueling facility capital cost--low		$ 45,000	$ 142				-
22		Maintenance facility modification capital cost--low		$ -	$ 75				-
23		**Total facility capital costs--low**		**$ 45,000**	**$ 217,**				-
24									
25									
26		Fueling facility capital cost--high		$ 55,000	$ 332				-
27		Maintenance facility modification capital cost--high		$ -	$ 175				-
28		**Total facility capital costs--high**		**$ 55,000**	**$ 507,**				-

In this example, the transit agency already has some CNG fueling facilities, so minor modifications are necessary. A value of $50,000 is entered into the grey cell for user-specific data. This value will override the default data.

The user decides to enter in $0 for maintenance facility modifications since the agency already has the facilities required for CNG buses

In this example, the resulting costs for the facility are $50,000

Transit Costs 1.0 User Optional Inputs: Median Costs Worksheet

This worksheet calculates capital and operating costs.

User can accept default values for bus replacement costs and maintenance costs (per mile) or can input information specific to the transit agency

		Diesel	CNG	LNG	Biodiesel 20	Ethanol	LPG	Hybrid
	COSTS--MEDIAN							
	10-bus example case							
	CAPITAL COSTS							
	Vehicle replacement							
	Incremental cost per bus--median		$ 49,500	$ 40,000	$ -	$ 30,000	$ 15,000	$ 116,000
	Base cost per bus							
	Default estimate	$ 290,000	$ 339,500					,000
	User-specific estimate							
	State sales tax: 7.75%	$ 22,475	$ 26,311	$ 25,575				,465
	Total cost per bus	$ 312,475	$ 365,811	$ 355,575				,465
	Total vehicle replacement costs	**$ 3,124,750**	**$ 3,658,113**	**$ 3,555,750**				**650**
	Total facility costs	**$ -**	**$ 50,000**	**$ 362,000**	**$ -**	**$ 125,000**	**$ 247,000**	**$ -**
	Total capital costs--median	**$ 3,124,750**	**$ 3,708,113**	**$ 3,917,750**	**$ 3,124,750**	**$ 3,573,000**	**$ 3,533,375**	**$ 4,374,650**
	OPERATING COSTS							
	Fuel Costs							
	Fuel economy (mi/sales unit)	4.00 mpg_{diesel}	2.15 $mp\,therm_{CNG}$	1.89 mpg_{LNG}	3.60 $mpg_{biodiesel}$	2.21 $mpg_{ethanol}$	1.95 mpg_{lpg}	4.55 mpg_{hybrid}
	Fuel price per gallon--median	$ 1.2229	$ 0.9008	$ 0.6900	$ 1.2406	$ 1.3532	$ 1.1723	$ 1.2229
	Fuel cost per mile	$ 0.31	$ 0.42	$ 0.37	$ 0.34	$ 0.61	$ 0.60	$ 0.27
	Annual fleet fuel cost	$ 127,391	$ 174,902	$ 152,150	$ 143,413	$ 255,565	$ 250,500	$ 112,104
	Maintenance Costs							
	Maintenance cost per mile							
	Default estimate*	$ 0.42	$ 0.50	$ 0.52	$ 0.42	$ 0.55	$ 0.48	$ 0.42
	User-specific estimate							
	Annual fleet maintenance cost	$ 175,001	$ 208,252	$ 215,252	$ 175,001	$ 227,502	$ 201,252	,001
	Annual fueling facility compression electricity cost		$ 15,800					
	Annual fueling facility maintenance cost	$ 5,900	$ 3,500	$ 13,3				
	Other annual operating costs	$ -	$ -	$				
	Total annual maintenance cost	$ 180,901	$ 227,552	$ 228,5				
	Operating cost per mile--median	**$ 0.74**	**$ 0.97**	**$ 0.9**				
	Total annual operating costs--median	**$ 308,000**	**$ 402,000**	**$ 381,0**				

In this example, the user accepts the default bus costs that will be used to determine total costs.

No data is yet available for maintenance costs of fully commercial biodiesel and hybrid bus fleets. As a result, the default cost is **currently** set equal to diesel.

Transit Costs 1.0 Results

Results are displayed in charts and worksheets. Examples are provided on the following slides.

Charts

1. Annualized Cost for all Fuels
2. Local Share of Annualized Cost for all Fuels
3. Incremental Cash Flow for an Alternative Fuel
4. Annualized Cost Breakdown for all Fuels
5. Fuel Costs for all Fuels

Worksheets

Comparisons for All Fuels

- Capital
- Operating (per mile and annual)
- Total costs (per mile and annualized)
- Local share (per mile and annualized)
- Low, Median, and High Cost worksheets
- Emission reductions for NOx, and PM

Cash Flow for Diesel and Alternative Fuel

- Year by year comparison of diesel and an alternative fuel
- Provides comparison for:
  - bus costs
  - facility costs
  - maintenance costs
  - fueling costs
  - total operating costs
  - total costs
  - local share of costs

Transit Costs 1.0 Result Worksheets: Median Cost Comparison for all fuels

Worksheet provides breakdown and total capital and operating expenses, including local share

		Diesel	CNG	LNG	Biodiesel 20	Ethanol	LPG	Hybrid
	COSTS--MEDIAN							
	10-bus example case							
	CAPITAL COSTS							
	Vehicle replacement							
	Incremental cost per bus--median		$ 49,500	$ 40,000	$ -	$ 30,000	$ 15,000	$ 116,000
	Base cost per bus							
	Default estimate	$ 290,000	$ 339,500	$ 330,000	$ 290,000	$ 320,000	$ 305,000	$ 406,000
	User-specific estimate							
	State sales tax: 7.75%	$ 22,475	$ 26,311	$ 25,575	$ 22,475	$ 24,800	$ 23,638	$ 31,465
	Total cost per bus	$ 312,475	$ 365,811	$ 355,575	$ 312,475	$ 344,800	$ 328,638	$ 437,465
	Total vehicle replacement costs	**$ 3,124,750**	**$ 3,658,113**	**$ 3,555,750**	**$ 3,124,750**	**$ 3,448,000**	**$ 3,286,375**	**$ 4,374,650**
	Total facility costs	**$ -**	**$ 50,000**	**$ 362,000**	**$ -**	**$ 125,000**	**$ 247,000**	**$ -**
	Total capital costs--median	**$ 3,124,750**	**$ 3,708,113**	**$ 3,917,750**	**$ 3,124,750**	**$ 3,573,000**	**$ 3,533,375**	**$ 4,374,650**
	OPERATING COSTS							
	Fuel Costs							
	Fuel economy (mi/sales unit)	4.00 mpg_{diesel}	2.15 $mp\ therm_{CNG}$	1.89 mpg_{LNG}	3.60 $mpg_{biodiesel}$	2.21 $mpg_{ethanol}$	1.95 mpg_{lpg}	4.55 mpg_{hybrid}
	Fuel price per gallon--median	$ 1.2229	$ 0.9008	$ 0.6900	$ 1.2406	$ 1.3532	$ 1.1723	$ 1.2229
	Fuel cost per mile	$ 0.31	$ 0.42	$ 0.37	$ 0.34	$ 0.61	$ 0.60	$ 0.27
	Annual fleet fuel cost	$ 127,391	$ 174,902	$				112,104
	Maintenance Costs							
	Maintenance cost per mile							
	Default estimate*	$ 0.42	$ 0.50	$				0.42
	User-specific estimate							
	Annual fleet maintenance cost	$ 175,001	$ 208,252					175,001
	Annual fueling facility compression electricity cost		$					
	Annual fueling facility maintenance cost	$ 5,900		$				5,900
	Other annual operating costs	$		$				-
	Total annual maintenance cost	$ 180,901	$ 227,552	$ 228,552	$ 180,901	$ 233,502	$ 207,252	$ 180,901
	Operating cost per mile--median	**$ 0.74**	**$ 0.97**	**$ 0.91**	**$ 0.78**	**$ 1.17**	**$ 1.10**	**$ 0.70**
	Total annual operating costs--median	**$ 308,000**	**$ 402,000**	**$ 381,000**	**$ 324,000**	**$ 489,000**	**$ 458,000**	**$ 293,000**

Per mile costs are provided because many transit operators prefer using them over annual costs

Transit Costs 1.0 Result Worksheets: Median Cost Comparison for all fuels

Worksheet also provides fleet emission reduction estimates for NOx and PM from a current diesel fleet baseline.

If the user is considering alternative fuel procurement several years away, future expected emissions for the diesel baseline and alternative fuels may be entered into the worksheet instead of current values.

	A B C	D	E	F	G	H
1		COSTS--MEDIAN				
2		10-bus example case				
3						
4		Diesel	CNG	LNG	Biodiesel 20	Ethanol
53						
54	**EMISSIONS CALCULATIONS**					
55	Emissions rate (g NOx/bhp-hr)	2.0	1.8	1.8	2.2	2.0
56	Conversion factor (bhp-hr/mile)	4.3	4.3	4.3	4.3	4.3
57	Emissions rate (g NOx/mile)	8.6	7.7	7.7	9.5	8.6
58	Annual emissions (tons NOx/yr)	3.9	3.6	3.6	4.3	3.9
59	**Fleet emissions reduced (tons NOx/year)**		0.4	0.4	(0.4)	0.0
60						
61	Emissions rate (g PM/bhp-hr)[k]	0.05	0.03	0.03	0.01	0.05
62	Conversion factor (bhp-hr/mile)	4.3	4.3	4.3	4.3	4.3
63	Emissions rate (g PM/mile)	0.22	0.13	0.13	0.02	0.22
64	Annual emissions (tons PM/yr)	0.10	0.06	0.06	0.01	0.10
65	**Fleet emissions reduced (tons PM/year)**		0.04	0.04	0.09	0.00

Transit Costs 1.0 Result Worksheets: Cash Flow

Worksheet provides a year-by-year analysis of cash outlay over 12 years (life of buses) for diesel and the alternative fuel chosen in the General Inputs Module

Remember back to inputs:
-Transit agency purchasing 10 buses
-Acquisition in 2004 and 2005.
-Facility costs are minimal due to existing CNG fleet

YEARLY COST SUMMARY (CASH-FLOW ANALYSIS)

10-bus example case

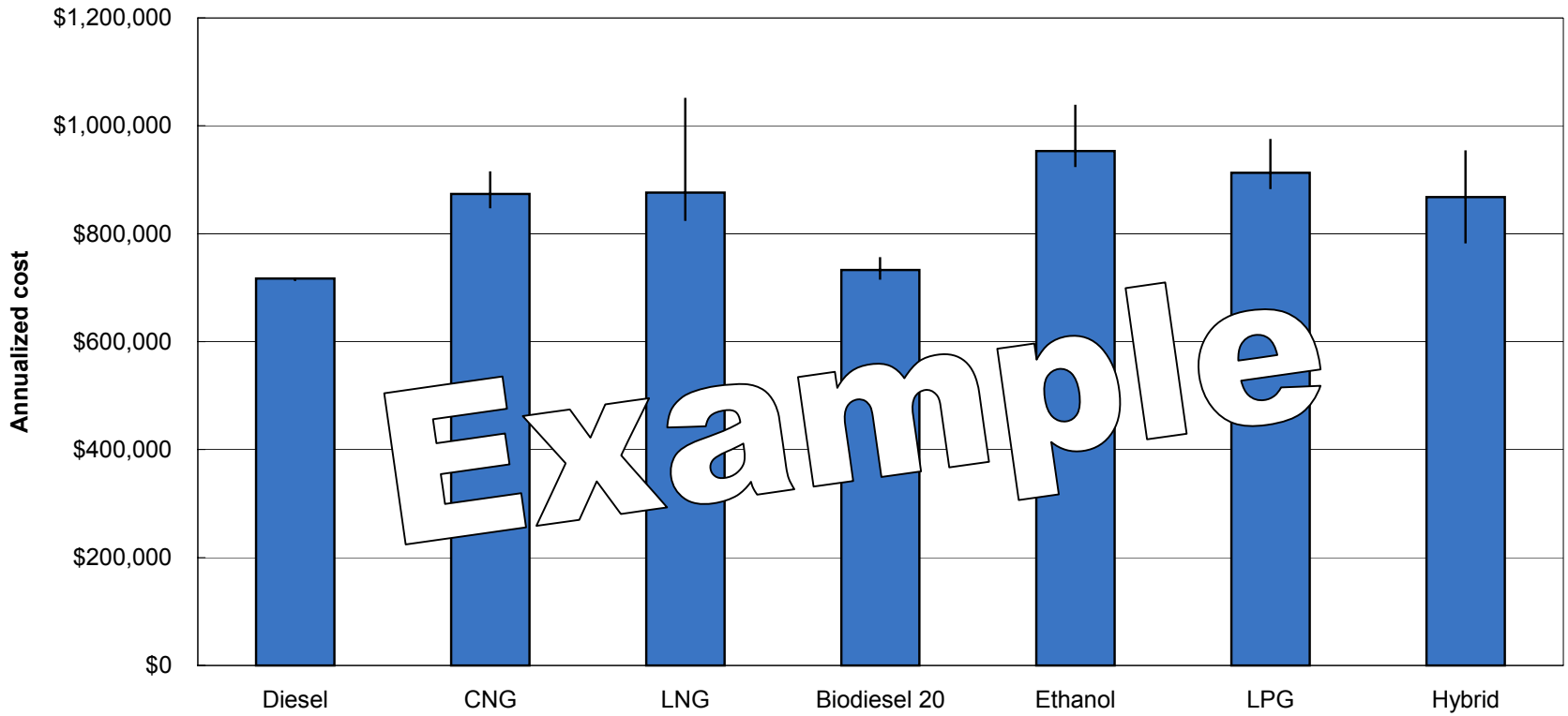
		2003	2004	2005	2006	2007
5	**DIESEL**					
6	Total cost per bus	$ 312,475	$ 312,475	$ 312,475	$ 312,475	$ 312,475
7	Number of buses	0	5	5	0	0
8	Bus replacement costs	$ -	$ 1,562,375	$ 1,562,375	$ -	$ -
9	Facilities costs	$ -	$ -	$ -	$	$ -
10	Maintenance costs	$ -	$ 93,401	$ 180,901	$ 18	$ 180,901
11	Fueling costs	$ -	$ 63,696	$		27,391
12	Total operating costs	$ -	$ 157,096	$		08,293
13	**Total costs**	**$ -**	**$ 1,719,000**	**$**		**8,000**
14	**Local share**	**$ -**	**$ 470,000**	**$**		**8,000**
15						
16	**CNG**					
17	Total cost per bus--median	$ 365,811	$ 365,811	$		65,811
18	Number of buses	0	5	5	0	0
19	Bus replacement costs--median	$ -	$ 1,829,056	$ 1,829,056	$ -	$ -
20	Facilities costs--median	$ -	$ 50,000	$ -	$ -	$ -
21	Maintenance costs	$ -	$ 115,526	$ 227,552	$ 227,552	$ 227,552
22	Fueling costs	$ -	$ 87,451	$ 174,902	$ 174,902	$ 174,902
23	Operating costs--median	$ -	$ 202,977	$	$ 402,453	$ 402,453
24	**Total costs--median**	**$ -**	**$ 2,082,000**	**$**		**00**
25	**Local share**	**$ -**	**$ 579,000**	**$**		**00**

Cash-flow only indicates actual cash outlays during the year. An annualized result would indicate bus costs in out years

Note that facility costs occur in first year of purchase

Transit Costs 1.0 Result Chart: Annualized Cost Comparison

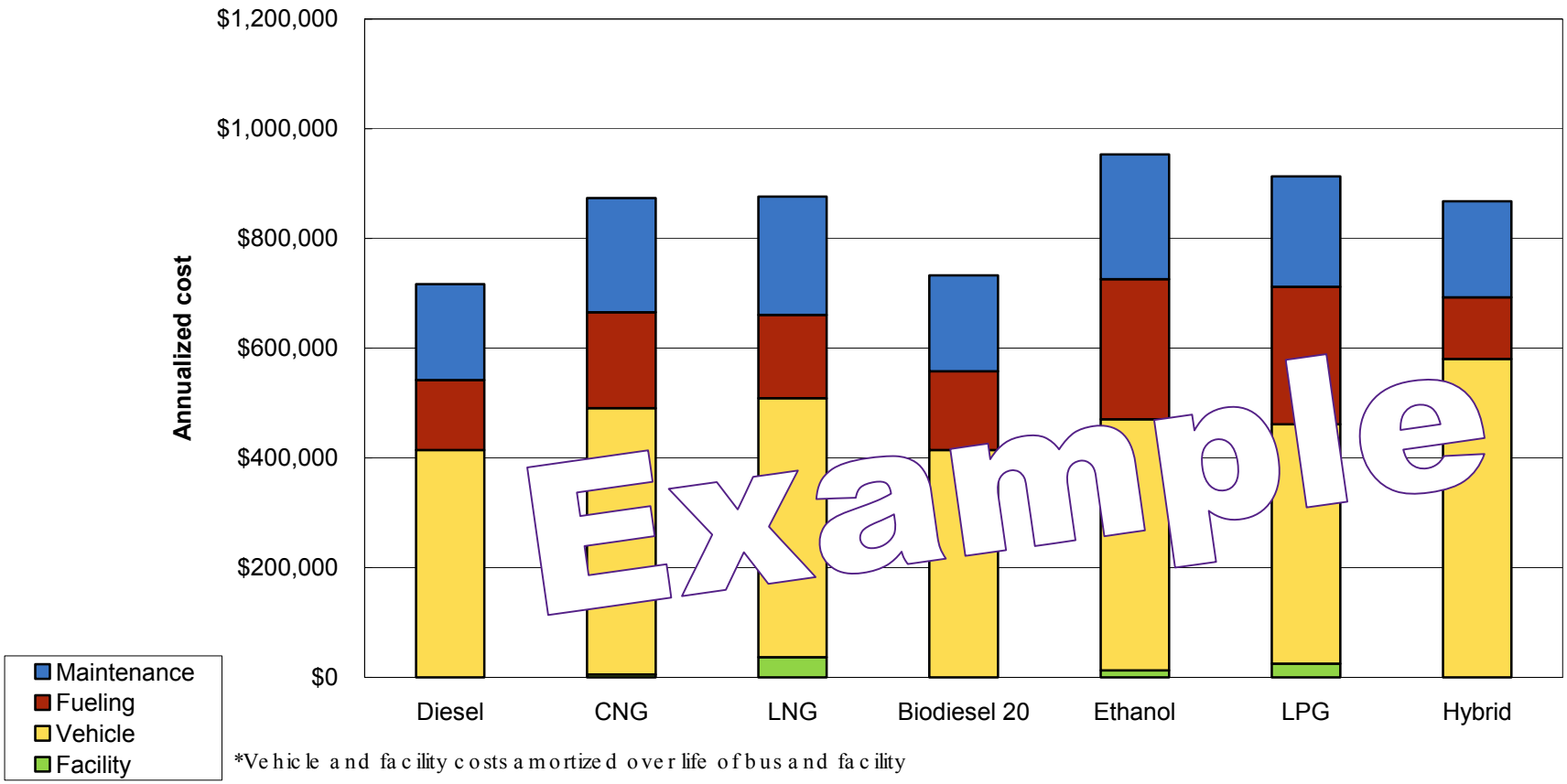
Annual operating costs and annualized vehicle and facility costs are summed to show a total annualized cost for each fuel option. A second chart shows the local share of these costs (same proportions as the total annualized cost)



*Include annual operating costs and vehicle and facility costs amortized over life of bus and facility.

Transit Costs 1.0 Result Chart: Annualized Cost Comparison Breakdown

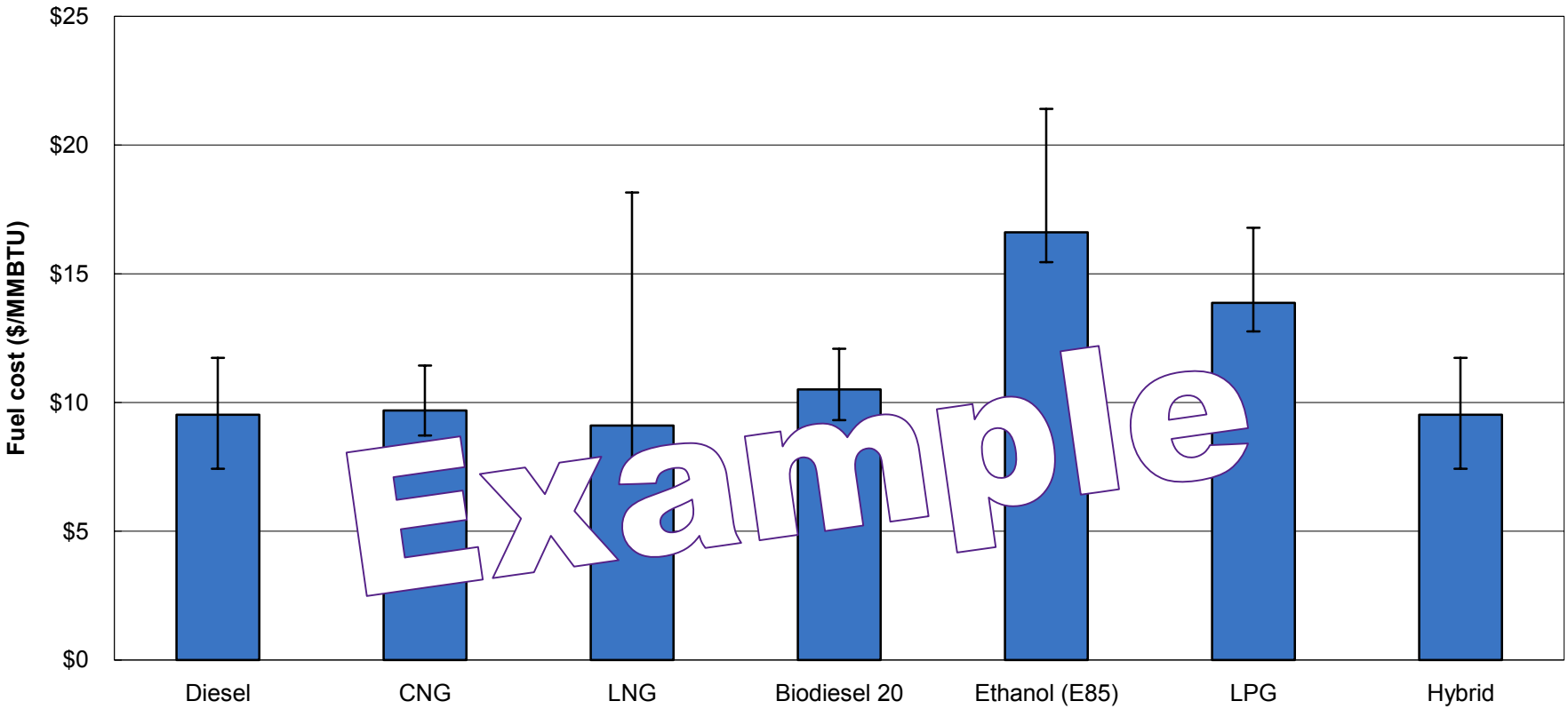
Annual operating costs and annualized vehicle and facility costs are summed to show a total annualized cost for each fuel option



*Vehicle and facility costs amortized over life of bus and facility

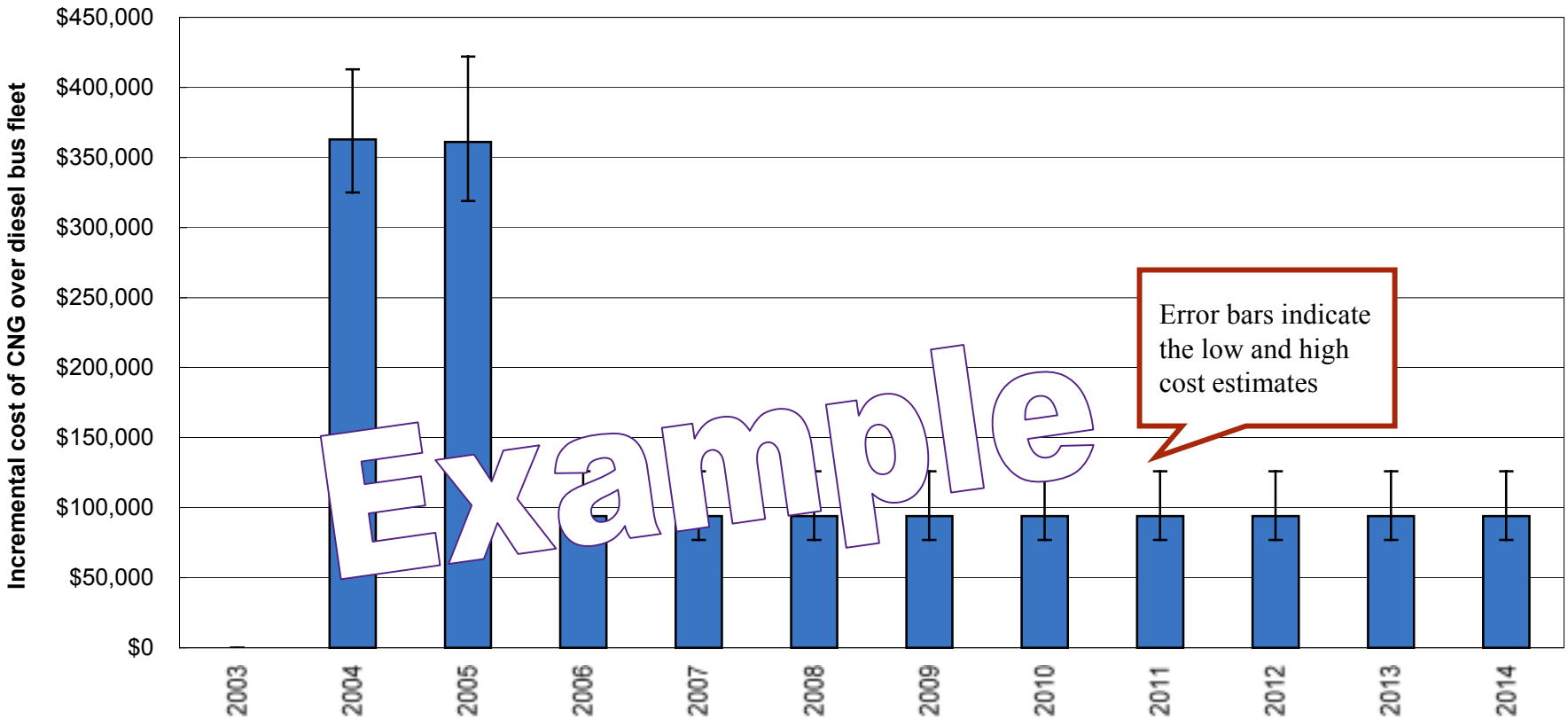
Transit Costs 1.0 Result Chart: Fuel Cost Comparison

Fuel costs per energy unit (million Btu) are compared for different fuels.
This chart compares fuels directly without including vehicle fuel efficiency.



Transit Costs 1.0 Result Chart: Incremental Cash Flow

The cash flow charts (total and local share) indicate the incremental increase or decrease in costs for the alternative fuel fleet compared with a diesel fleet. In this example, 10 CNG buses are purchased over two years.



Transit Costs 1.0: Conclusions

- This tool can be used by Clean Cities Coordinators to better understand the cost differences between various fuel and technology choices faced by transit agencies
- Fuel options have been updated to reflect current trends and interests in alternative fuels for transit fleets, but the tool is left open for users to enter in their own data
- The entire tool can be customized for region- and agency-specific parameters
- The current baseline is today's diesel buses, but the tool can be customized to account for "clean-diesel" technologies

For assistance using the Transit Cost 1.0 tool, please contact:

- Jon Leonard, 949-833-7131 (leonard.jon@tiaxllc.com)
- Robb Barnitt, 949-833-7130 (barnitt.robb@tiaxllc.com)
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